Search for GMSB SUSY in diphoton events with large missing ET

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Outline

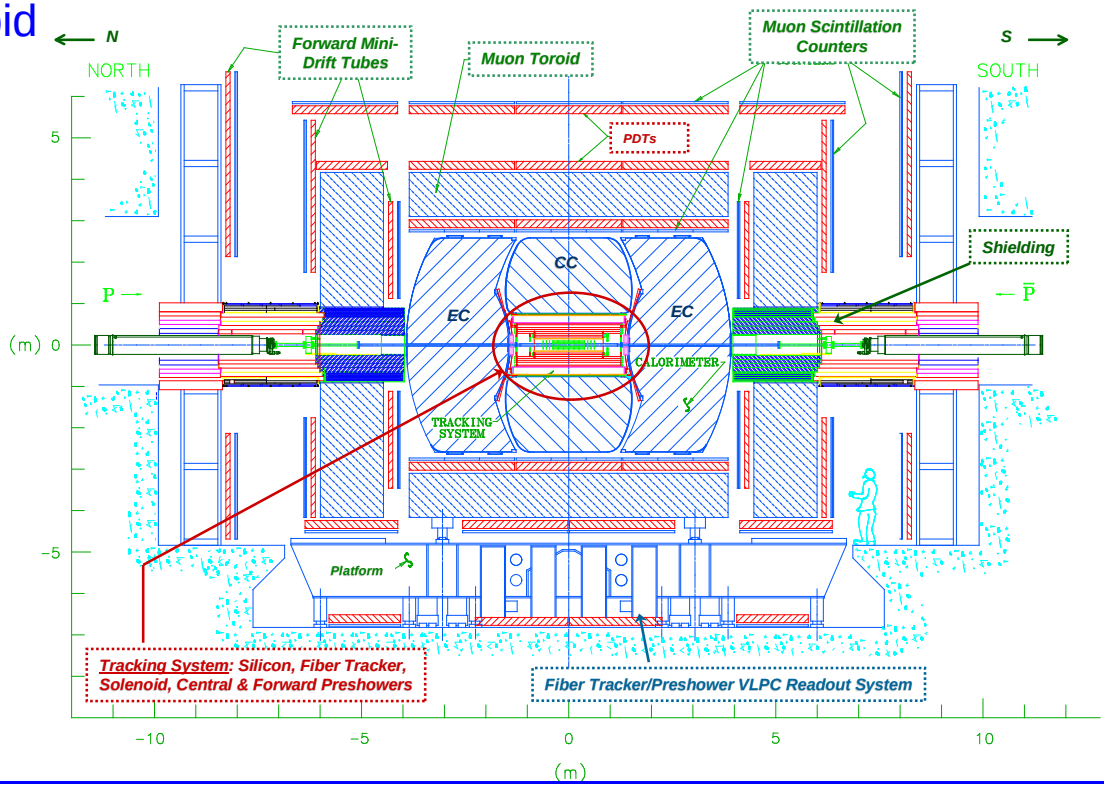
- ☆ DØ detector and data sample
- ☆ GMSB and $\gamma\gamma + \not\!\!E_T$ final state
- ☆ Event selection
- ☆ Background estimation
- ☆ Limit calculation
- ☆ Summary

Tevatron Run II and the DØ detector

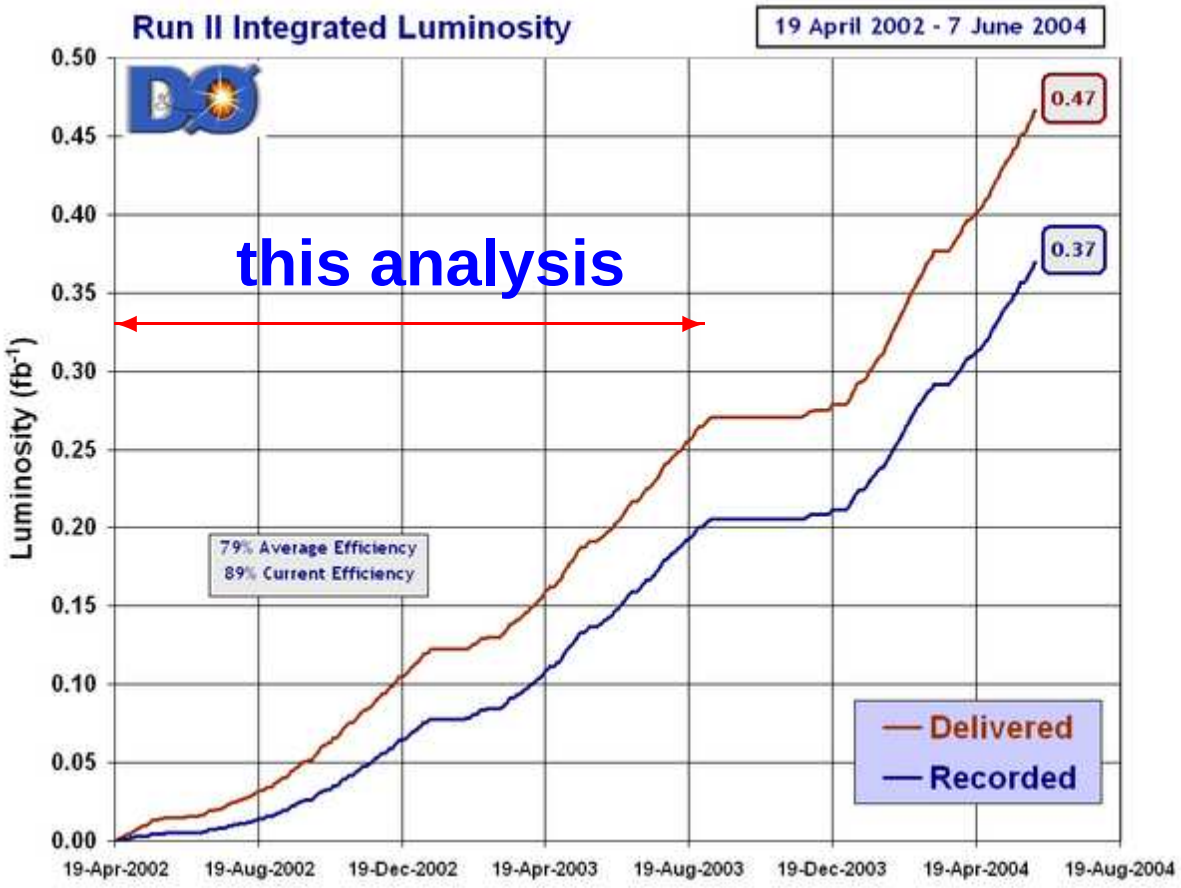
☆ Fermilab Tevatron: $p\bar{p}$ collider, 1.96 TeV center-of-mass energy, bunch crossing every 396 ns, current instantaneous luminosity $0.7 \cdot 10^{32} \mathrm{cm}^{-2}\mathrm{s}^{-1}$

☆ DØ upgrade:

- 2 T superconducting solenoid
- silicon detector
- fiber tracker
- preshower detector
- upgraded muon system
- new calorimeter electronics
- upgraded trigger and DAQ



Luminosity and data sample



☆ This analysis: data collected between April 2002 and October 2003

☆ Integrated luminosity: 185 pb^{-1}

Gauge mediated Supersymmetry breaking (GMSB)

- ☆ One of the possible scenarios of SUSY breaking, as gravity and anomaly mediated alternatives (SUGRA and AMSB)
- ☆ SUSY breaking propagated through gauge interactions via new messenger fields at scale $\Lambda \ll \mathrm{M_{Planck}}$
- ☆ Gravitino ($\tilde{G}$) is the lightest supersymmetric particle (LSP): $\mathcal{O}(10^{-2})$ eV $< m_{\tilde{G}} <$ 1 keV
- ☆ Next-to-lightest particle (NLSP) is either the lightest neutralino or a charged slepton
- ☆ If the NLSP is the neutralino: $\tilde{\chi}_1^0 \rightarrow \gamma\tilde{G}$
- ☆ Minimal set of parameters: scale Λ, messenger mass scale M_m, number of messenger fields N_5, ratio of Higgs v.e.v. $\tan\beta$, sign of Higgs mass term μ

Production and final state

☆ Mostly produced in $\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}$ and $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^{0}$ decays

☆ $p\bar{p}(\rightarrow \text{gauginos}) \rightarrow \tilde{\chi}_1^0\tilde{\chi}_1^0 + X \rightarrow \gamma\gamma + \tilde{G}\tilde{G} + X$

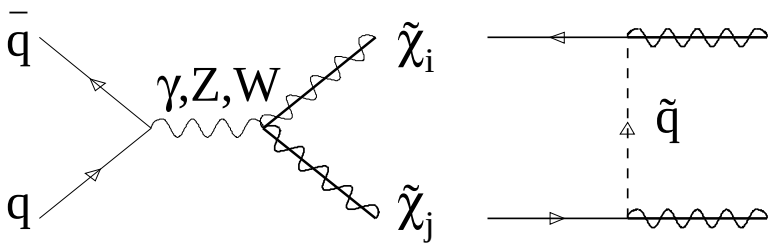
$\Rightarrow$ distinctive experimental signature (assuming a short neutralino lifetime):

two photons and missing transverse energy ($\not\!\!E_T$)

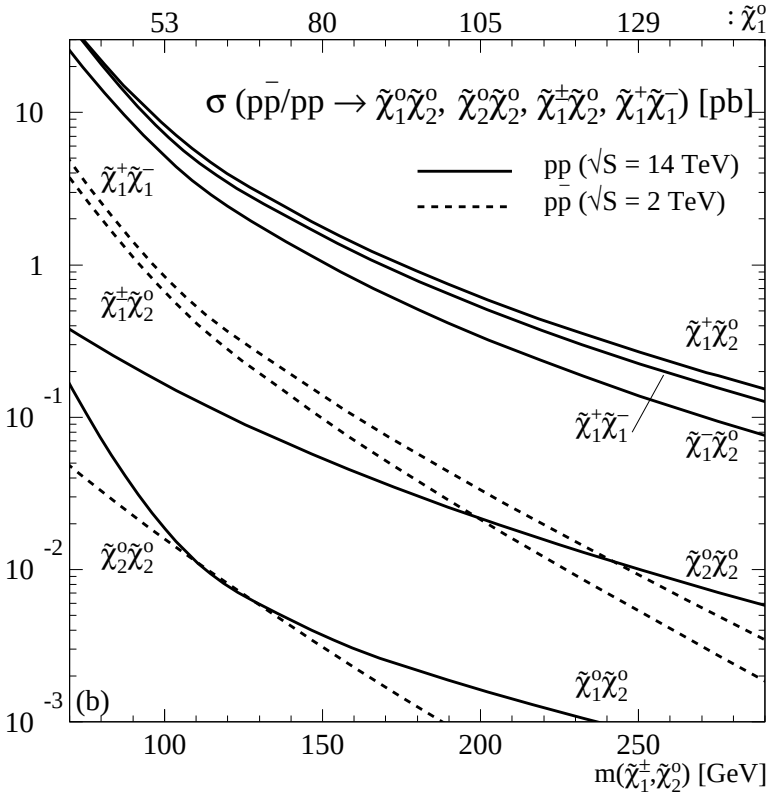
☆ Current lower limits on neutralino masses:

$m_{\tilde{\chi}_1^0} > 65$ GeV by CDF, > 75 GeV by DØ,

> 100 GeV by LEP2



Beenakker *et al* PRL **83**, 3780 (1999)



Inclusive search for $\gamma\gamma + \not\!\!E_T$

- ☆ Use single and di-electromagnetic triggers (97% efficient)
- ☆ Select events with 2 photons in Central Calorimeter ($|\eta_\gamma| < 1.1$):
  - satisfy energy deposition isolation
  - shower shape consistent with photon
    $\rightarrow$ di-EM identification efficiency 85.9% (from $Z \rightarrow ee$)
  - $E_T > 20$ GeV
  - electron veto: no matching track (94.2% efficient)
  - track isolation in hollow cone around EM object ($\sum$ track $p_T < 2$ GeV)
- ☆ $\not\!\!E_T$ corrected for EM and jet energy scales
- ☆ $\not\!\!E_T$ not back-to-back with the leading jet and not colinear with both photons

Standard Model backgrounds

☆ Backgrounds with $\not\!\!E_T$ due to mismeasurement:

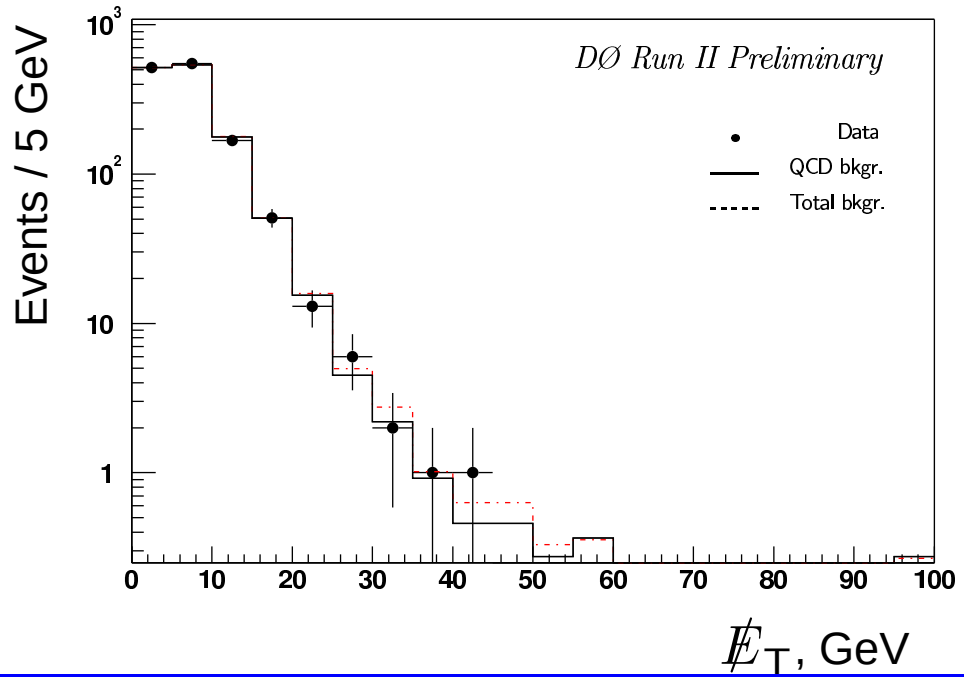
- mostly QCD with direct photons or jets misidentified as photons
- Drell-Yan, with electrons misreconstructed as photons due to tracking inefficiency

☆ Backgrounds with true $\not\!\!E_T$:

- dominant: $W\gamma \rightarrow e\nu\gamma$ (missed track) and Wjet $\rightarrow e\nu$ "γ" (jet mis-id'ed as photon)
- $Z \rightarrow \tau\tau \rightarrow ee + X$
- $t\bar{t}$, WW, WZ, etc.

Background: QCD sample

- ☆ Used to estimate background without true $\not\!\!E_T$ (accounts for Drell-Yan)
- ☆ Same data sample and analysis cuts, but photon candidates are required to fail the shower shape cut
- ☆ $\not\!\!E_T$ shape measured in this sample
- ☆ Normalization to diphoton sample done in $\not\!\!E_T < 15$ GeV bin



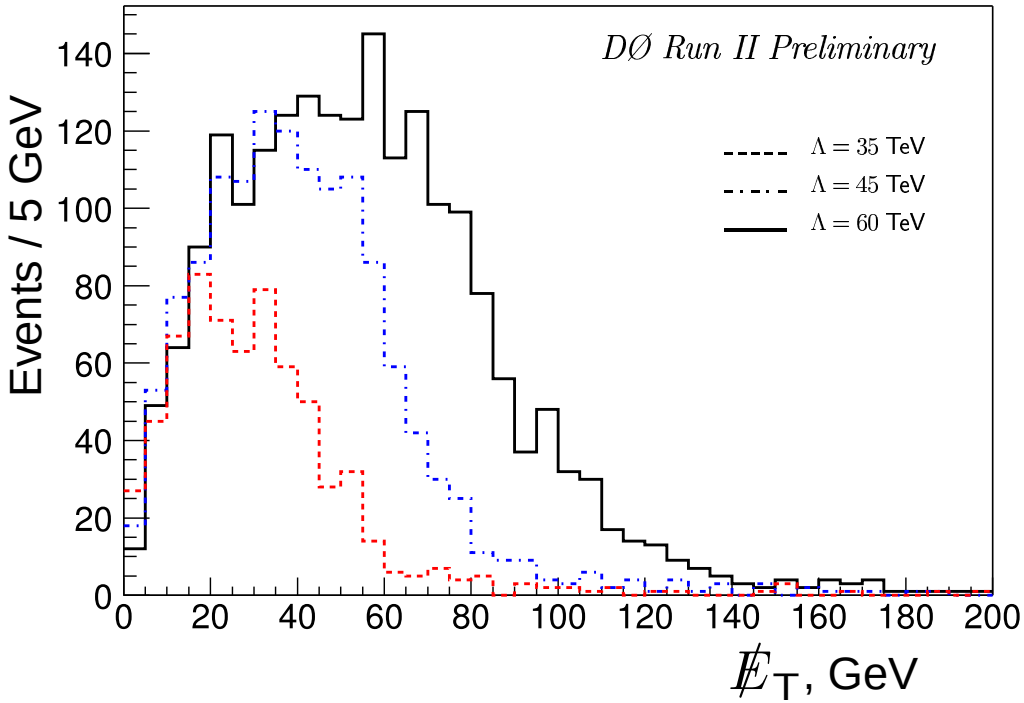
Background: $e\gamma$ sample

- ☆ Electron background estimation
- ☆ Same sample and cuts as diphoton, except one EM object has a track match and electron track isolation
- ☆ Remove QCD contribution (same method as for diphoton)
- ☆ Multiply number of observed $e\gamma$ by the ratio $(1-\epsilon_{\text{trk}})/\epsilon_{\text{trk}}$ (where ϵ_{trk} is the track matching efficiency) of probabilities for an electron to be mis-id'ed as a photon or identified as an electron

$\not\!\!E_{\text{T}}$	$>$ 30 GeV	$>$ 40 GeV	$>$ 50 GeV
$\gamma\gamma$ events	4	1	0
QCD	5.2 ± 0.7	2.1 ± 0.4	1.2 ± 0.3
$e\gamma$	0.9 ± 0.2	0.4 ± 0.1	0.1 ± 0.1
Total BG	6.1 ± 0.7	2.5 ± 0.5	1.3 ± 0.3

Signal simulation

- ☆ Sparticles mass spectrum and branching fractions from ISAJET v7.58
- ☆ Total leading order cross section and event generation from PYTHIA v6.202
- ☆ K-factors for next-to-leading order cross sections from Beenakker *et al*
  Phys. Rev. Lett. **83**, 3780 (1999)
- ☆ Full detector simulation
- ☆ Signal considered: $M_m = 2\ \Lambda$
  $N_5 = 1$, $\tan\beta = 5$, $\mu > 0$
- ☆ Optimize for significance
  $\Rightarrow$ optimal cut $\not\!\!E_T > 40$ GeV



Limit calculation

☆ No excess observed in $\not\!\!E_T$ distribution: observed 1, expected 2.5 $\pm$ 0.5

☆ Set limit on Λ using Bayesian approach:

$\Lambda > 78.8$ TeV at 95% C.L.

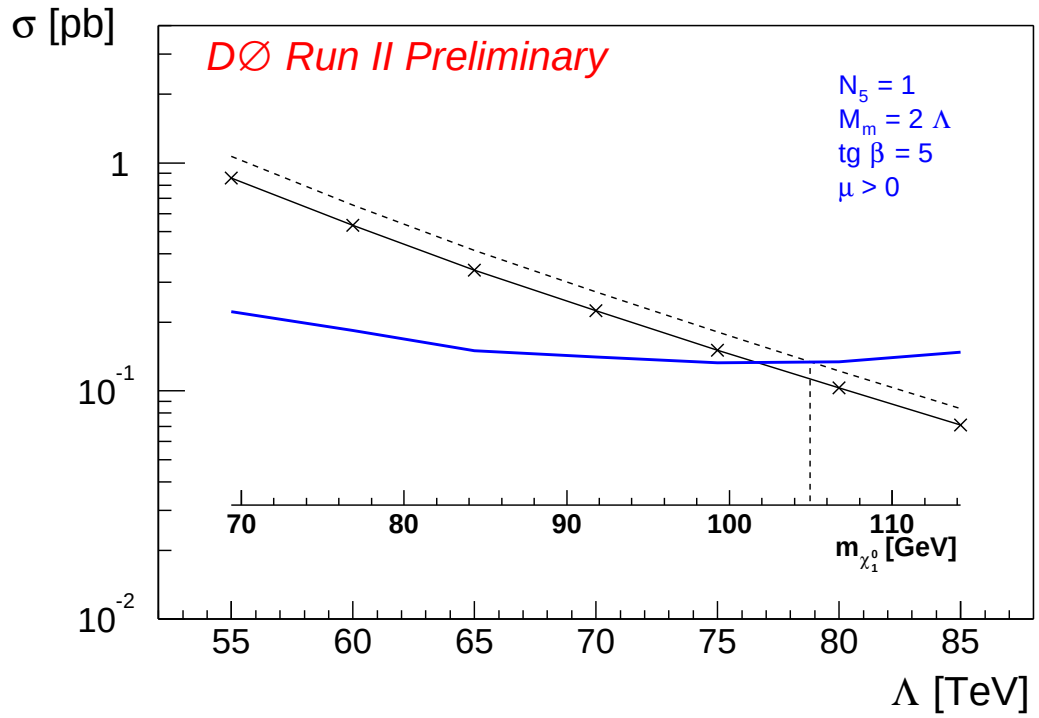
or, in terms of gaugino masses:

$m_{\tilde{\chi}_1^0} > 105$ GeV and

$m_{\tilde{\chi}_1^\pm} > 192$ GeV

World's best limits

in this class of model



CDF preliminary result (202 pb^{-1} and $\tan\beta = 15$): $\Lambda > 69$ TeV, $m_{\tilde{\chi}_1^0} > 93$ GeV, $m_{\tilde{\chi}_1^\pm} > 168$ GeV

Summary and outlook

- ☆ DØ has searched for diphoton events with large missing transverse energy
- ☆ No evidence for GMSB signal but...
- ☆ New limits were set, most stringent to date for this class of models
- ☆ Outlook
  - already much more data available and more is coming
  - good prospects for new analyses with exclusive final states
  - photon pointing using high calorimeter segmentation. Use preshower information for non-pointing photons (due to finite $\tilde{\chi}_1^0$ lifetime)
  - use other model parameters (including Snowmass model line)